Integrated Neuroscience Program
An Alternative Approach to Teaching Neurosciences to Chiropractic Students

Xiaohua He, MD, **James La Rose**, MD, and **Niu Zhang**, MD, Palmer College of Chiropractic Florida

Purpose: Most chiropractic colleges do not offer independent neuroscience courses because of an already crowded curriculum. The Palmer College of Chiropractic Florida has developed and implemented an integrated neuroscience program that incorporates neurosciences into different courses. The goals of the program have been to bring neurosciences to students, excite students about the interrelationship of neuroscience and chiropractic, improve students' understanding of neuroscience, and help the students understand the mechanisms underpinning the chiropractic practice. This study provides a descriptive analysis on how the integrated neuroscience program is taught via students' attitudes toward neuroscience and the comparison of students' perceptions of neuroscience content knowledge at different points in the program. **Methods:** A questionnaire consisting of 58 questions regarding the neuroscience courses was conducted among 339 students. The questionnaire was developed by faculty members who were involved in teaching neuroscience and administered in the classroom by faculty members who were not involved in the study. **Results:** Student perceptions of their neuroscience knowledge, self-confidence, learning strategies, and knowledge application increased considerably through the quarters, especially among the 2nd-year students. **Conclusions:** The integrated neuroscience program achieved several of its goals, including an increase in students' confidence, positive attitude, ability to learn, and perception of neuroscience content knowledge. The authors believe that such gains can expand student ability to interpret clinical cases and inspire students to become excited about chiropractic research. The survey provides valuable information for teaching faculty to make the course content more relevant to chiropractic students. (J Chiropr Educ 2009;23(2):134–146)

Key Indexing Terms: chiropractic; neurosciences; teaching; questionnaires

INTRODUCTION

Chiropractors have applied spinal manipulation since its emergence in the late 19th century to treat visceral and musculoskeletal disorders.[1,2] Although the term "subluxation" in the vertebral column is used to explain the causation of disease and the effectiveness of spinal manipulation,[1–3] no robust basic neurophysiologic rationale has yet emerged to explain what are widely accepted as the beneficial effects of chiropractic manipulation in the treatment of biomechanical disorders. Nonetheless, sufficient well-controlled clinical trials have appeared to support the use of manipulation in the treatment of low back pain, neck pain, and cervicogenic headache in appropriate circumstances.[4–6] Animal models have also been used in the studies of the mechanism of chiropractic manipulative therapy. For example, an animal model was established in an attempt to evaluate the results of experimental subluxation[7,8] and an animal model of manipulation was created in an attempt to investigate the effect of manipulation on paraspinal muscles.[9,10] All of these studies applied neuroanatomic and neurophysiologic techniques to elucidate the underlying neuronal mechanisms. Both clinical practice and basic chiropractic research signify the importance of the neurosciences in comprehending chiropractic concepts and basic science ideas.

It should come as no surprise that neuroscience is one of the most important subjects in chiropractic schools because such basic knowledge may

The Journal of Chiropractic Education
Copyright © 2009 the Association of Chiropractic Colleges
Vol. 23, No. 2. Printed in U.S.A.
1042-5055/$22.00

provide possible explanations underpinning chiropractic practice.[11] However, through an Internet search, we found that most of the chiropractic schools did not offer independent neurosciences courses. In the two schools that offered independent neurosciences courses, the total teaching hours were significantly less than the other basic science courses. It is understandable that the curricula of chiropractic schools are mostly only $3\frac{1}{2}$ calendar years, which is shorter than the typical 4-calendar-year curriculum of medical school. Also, current chiropractic students have much more to learn in these short $3\frac{1}{2}$ years than previous students did in years past.

Nonetheless, the interdisciplinary nature of neuroscience makes it one of the most fascinating and complex subjects to be addressed in the chiropractic classroom. To integrate neurosciences into different courses in an integrated curriculum seems to be a way to overcome the dwindling of teaching time. Therefore, Palmer College of Chiropractic Florida developed an integrated neuroscience program (INP) in the hope of stimulating the interest and knowledge of students in order to prepare them better for their career needs. However, the implementation of an INP is a challenge because of the different academic majors of students admitted and different backgrounds of faculty members recruited. The real challenge is how the teachers can provide practical and efficient ways to integrate the neurosciences into related courses relevant to chiropractic students.

To better define the present role of the INP, an inquiry-based survey was conducted among the students. The purposes of this assessment were first to evaluate if the INP would affect students' attitudes toward neuroscience and second to serve as a measurement for teachers by surveying the efficiency of different teaching methods in teaching neuroscience in order to develop more efficient strategies in their neuroscience teaching.

METHODS

The college uses the quarter system and there are 13 quarters in the entire curriculum. Students participating in this study were recruited from the 1st year (1st to 4th quarters) and 2nd year (5th to 8th quarters). Because of clinic commitment and difficulty in recruitment, students in the 3rd year and above (9th to 13th quarters) were not included in the survey. This study was approved by the institutional review board at the college. The survey questionnaire was created and distributed to all 1st- and 2nd-year students.

The survey was developed and validated by the two faculty members who were involved in teaching neuroscience and consisted of 58 questions. The survey was pilot tested by other faculty members and modifications were made per recommendations. The surveys were conducted at the beginning of each quarter by the faculty members who were not involved in teaching neuroscience. The instructions indicated that the purpose of the survey was to evaluate the influence of INP on students' attitude, perception of neuroscience content knowledge, and teaching effectiveness carried out at the college. We indicated that the definition of "integrated neuroscience" should encompass neuroanatomy, neurodevelopment, neurophysiology, neurochemistry, neuroimaging, neuropathology, and neurogenetics.

The survey questions were grouped into three sections. The first section, Description of Your Attitude Toward Neuroscience, addressed their overall impression of neuroscience as a result of INP taught at the college. In the second section, Your Neuroscience Content Knowledge, the perception of neuroscience content knowledge was asked. This section was used to make comparisons retrospectively between the students of the same quarter and between the students of different quarters. Students' perceived neuroscience content knowledge level at the 1st day of entering school was used as the baseline. In the final section, Integrated Neuroscience Program in Your Curriculum, the students were asked questions about the composition of neuroscience teaching. This section addressed how neuroscience was taught, what teaching methods and tools were used, and the effectiveness of the INP in learning neuroscience. The survey also solicited students' opinions about what factors would affect their attitude toward learning neuroscience. We assessed which factors were considered important in shaping INP as well as the goal of teaching neuroscience to chiropractic students.

To obtain a psychometric instrument to measure the results from the survey, a Likert-type scale was chosen for most of the questions. This instrument was selected because it has been shown to be both reliable and valid, and interpretation of the results is straightforward.[12] The Likert scale used in this study was "agree", "somewhat," and "disagree." Along with the Likert scale, a 10-point scale was also used in two questions to explore more detailed

information. Meanwhile, multiple-choice questions were used for three questions. Descriptive statistics were used to characterize percent response. A self-efficacy scale[13] was conducted to determine students' confidence in their neuroscience knowledge and their perceived ability to learn neuroscience. The appendix provides the questionnaire.

RESULTS

Complete surveys were received from 339 (78%) of 434 potential respondents, representing students from 1st quarter to 8th quarter (Table 1). Other demographic information is shown in Figure 1.

Students' Overall Attitude Toward Neuroscience

Overall, the students were very positive about the INP, especially the 2nd-year students. This is reflected by the different confidence levels throughout the quarters, being higher in the upper quarters (Fig. 2). Through the courses that were integrated with neuroscience, students overwhelmingly reported having valuable experience with the INP (Fig. 3A). As a result of integrating neuroscience into the different courses, students expressed more interest in neuroscience than previously (Fig. 3B). When the participants were asked if they would take more neuroscience courses if they had the opportunity, most students answered positively (Fig. 3C). Overall, participants felt more confident in neuroscience after taking the INP (Fig. 3D).

Table 1. Numbers and Percentage of Students Surveyed in Each Quarter

Quarter	1	2	3	4	5	6	7	8
Number	66	35	37	35	42	36	35	53
%	19	10	11	10	12	11	10	16

The majority of the surveyed students agreed that studying neuroscience was essential. Students were also positive about the value of neuroscience in chiropractic. The analysis of students' individual answers on their attitudes about the role of neuroscience in chiropractic showed that students had been most positive toward the role of neuroscience in the interpretation of the mechanisms of chiropractic therapy. However, they were less positive about neuroscience as the only way of obtaining facts (Table 2).

Multiple-choice responses to several of the variables that related to attitudes toward neuroscience are shown in Figure 4. Neuroscience courses provided through INP seemed to have the most influence on students' attitudes toward the neurosciences.

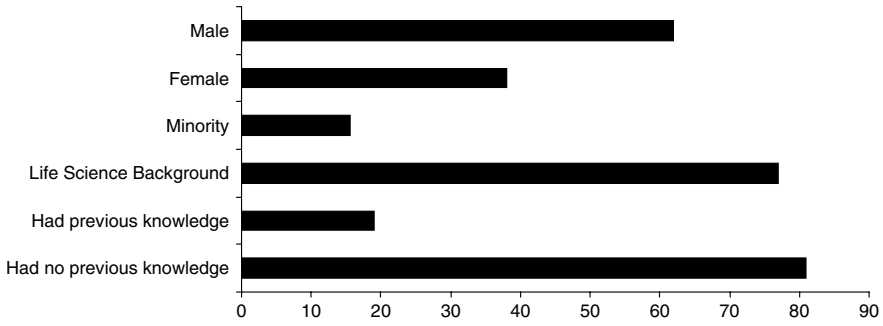

Figure 1. The demographic information about the students surveyed.

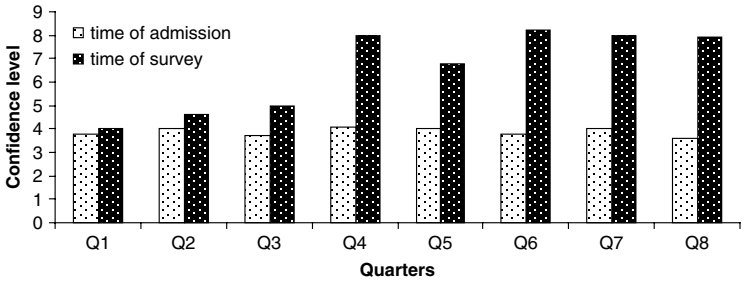

Figure 2. The distribution of confidence level in understanding of neuroscience at different quarters.

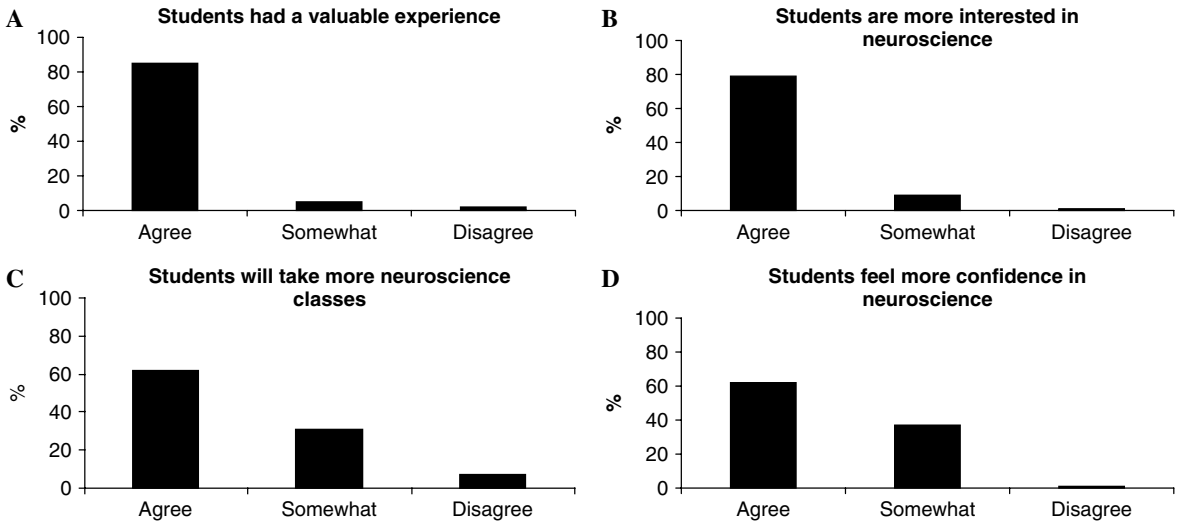

*Figure 3. Students' responses regarding attitudes toward the neurosciences. (**A**) More than 80% of the participants agreed that the program brought them valuable experience; (**B**) nearly 80% of the participants agreed that they were more interested in neuroscience as a result of the INP; (**C**) nearly 90% of the participants agreed or somewhat agree that they would take more neuroscience courses if given the opportunity; (**D**) almost all students agreed or somewhat agreed that they gained confidence after taking the program.*

Table 2. Attitudes of Students Toward Neuroscience

	No. (%) of students who		
Statements	Disagreed	Somewhat agreed	Agreed
Neuroscience gives us better understanding of chiropractic therapy	16 (5)	11 (3)	312 (92)
Every student has to be well acquainted with neuroscience knowledge	16 (5)	72 (21)	251 (74)
Neuroscience way of thinking is dull and boring to chiropractic	244 (72)	54 (16)	41 (12)
Neuroscience is the only way to explain chiropractic therapy	176 (52)	24 (7)	139 (41)

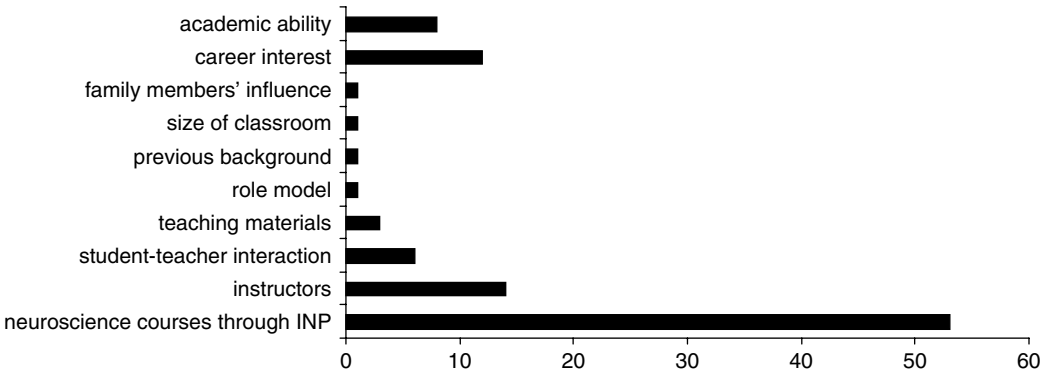

Figure 4. Responses pertaining to factors affecting student attitudes toward neuroscience (%).

Improvement of Neuroscience Content Knowledge

This study used the survey questionnaire instead of using actual examination scores to evaluate the students' perception of neuroscience content knowledge over quarters of their academic years after implementation of the INP. The study showed that as students learned more about the brain, spinal cord, and how the central nervous system interacted

with the peripheral nervous system, their perception of neuroscience content knowledge increased throughout quarters, especially in contrast to their knowledge at the time of admission (89% of the surveyed students had no or very low knowledge).

Of the 339 participants, the percentage of students who said they understood the topics listed in the questionnaire showed a trend to increase gradually and steadily through the 1st quarter to the 8th quarter (Fig. 5). For example, approximately 48% of 1st-year students (quarters 1–4) said that they understood the topics well or somewhat well. When broken down by quarters, only 19% of students in the 1st quarter acknowledged that they had some neuroscience knowledge, compared with 52% and 69% of students in the 3rd and 4th quarters, respectively. When broken down by years, over 80% of the 2nd-year students (quarters 5–8) agreed that they have increased in their neuroscience content knowledge as a result of the implementation of the INP, while only 46% of the 1st-year students said the same. We also solicited students' opinion about what factors would contribute to their improvement of neuroscience content knowledge and found that neuroscience knowledge learned through INP had the highest percentage (Fig. 6).

The survey also looked at the students' perceived content knowledge in structural (such as neuroanatomy) and functional neurosciences (such as neurophysiology, special sensory, and higher functions of the brain). Of all the participants in each quarter, the highest percentage of students who said they were comfortably familiar with functional neuroscience was in the 2nd-year students (36%, compared to 18% in the 1st-year students). While 50% of the 2nd-year students said they would consider themselves to know "somewhat" about the higher functions of the brain, 14% of them said they poorly understood the higher functions of the brain. Compared with 86% of the 2nd-year students and 46% of the 1st-year students who said they had comprehensive understanding of neuroanatomy, only 13% of these students said they had "somewhat" knowledge of higher brain function. Similar results

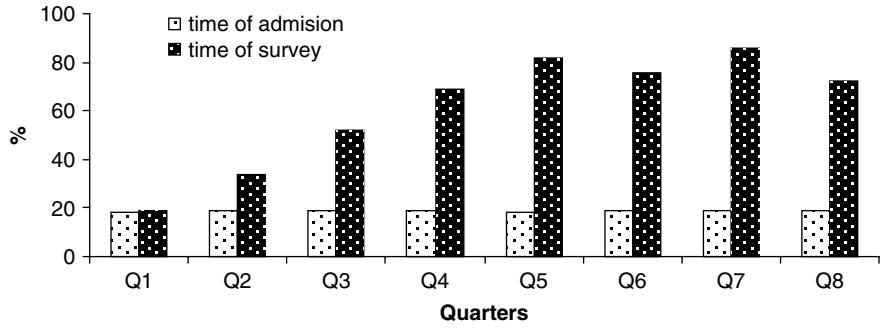

Figure 5. The percentage of students who agreed that they understood survey items about the neuroscience knowledge well in each quarter.

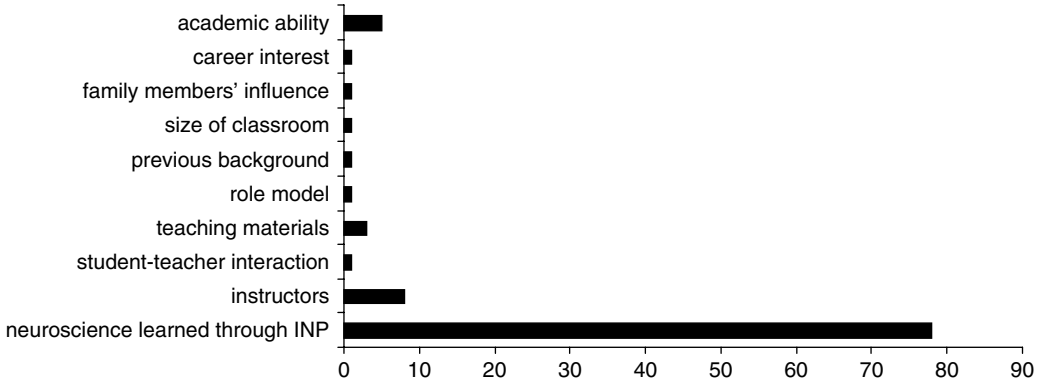

Figure 6. Percentage of students responding for each factor associated with improvement of neuroscience content knowledge.

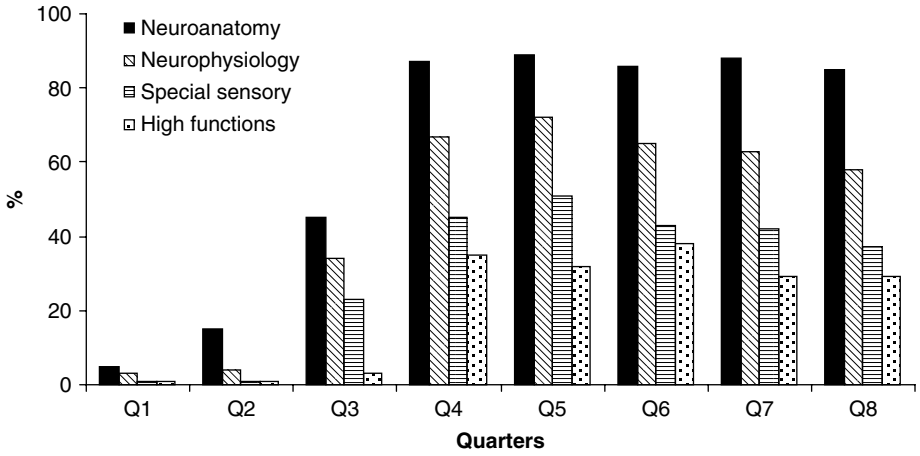

Figure 7. Percentages of students who agreed that they had a comprehensive understanding of different neuroscience content knowledge. Notice the higher percentage associated with neuroanatomy and neurophysiology and considerably lower percentage on special sensory and higher functions of the brain.

were also found in their perception of knowledge of special senses, with a considerably lower percentage of students agreeing with the statement of having a thorough understanding of the subject (Fig. 7).

Evaluation of Integrated Neuroscience Program

Students evaluated the INP and seemed to appreciate the integration of neurosciences into different courses. In each quarter, a high percentage (more than 86%) of students agreed that the INP was worth their time to learn neuroscience, compared to only 4% of participants who disagreed.

Students were provided with the different learning methods of learning neuroscience, including classroom teaching, laboratory (especially neuroanatomy), active learning sessions (ALS), and other sources (such as reading, Internet, and computer software programs). The survey found that the majority of students (83%) considered the classroom lectures as the main source of learning neuroscience. However, 76% of students agreed that the laboratory was a necessary supplement to classroom teaching. Seventy-eight percent of participants also agreed that they used the Internet, software, and self-study as other supplemental resources to study neuroscience, while only less than 10% of participants disagreed with these. As to the ALS, slightly more than half of the students (53%) were positive toward the ALS, 23% of students considered the ALS somewhat helpful, and 24% of students were negative toward the ALS. The purpose of the ALS was to provide students with opportunities to actively learn the subjects through case discussion, question-and-answer sessions, collaborative quizzes, oral presentation, and group study. The methods preferred by the students by quarter are shown in Figure 8.

DISCUSSION

The INP offered by the college is designed for students with little or no neuroscience knowledge who wish to pursue an interdisciplinary study of the function of the nervous system and its clinical relevance. This new milieu integrates the neurosciences into different courses with reduced teaching hours with an emphasis on the integration of basic neuroscience, increased clinical relevance, and self-directed learning. The study achieves several goals as discussed in the following text.

Exciting Students About Neuroscience

One of the important measured successes of the INP is the ability to boost students' positive attitudes toward neuroscience. The study showed that lower-quarter students had less confidence in learning neuroscience. Whether the INP could provide a potentially challenging, more motivating, and enjoyable approach is important to students' habits of learning neuroscience. According to the survey, students reported a gradual building of their

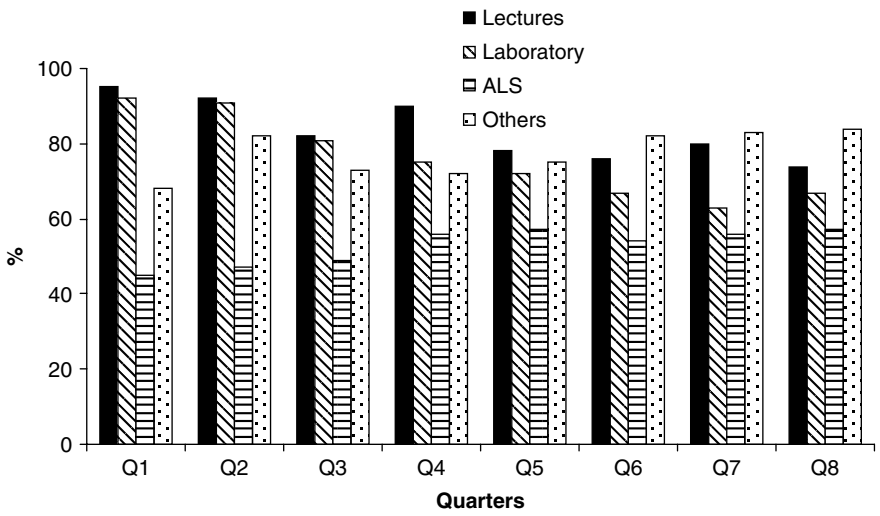

Figure 8. The percentage of students using different learning methods in each quarter.

positive attitude toward neuroscience throughout the quarters—a positive manifestation of the INP.

This success has been shown in several ways. First, the survey indicated that the improvement of participants' learning confidence level throughout the quarters was associated with the INP. According to the survey, the majority of students agreed that they had a valuable experience with the INP. When the survey specifically asked what element would be the major factor to affect the participants' attitudes toward the neurosciences, the neuroscience courses provided through INP were chosen by more than 55% of participants, much ahead of the percentage of participants who selected instructor or career interests. Second, the program did inspire students' interests about neuroscience. Overwhelmingly students expressed that they not only learned more about the function of the nervous system and its clinical relevance, but also were more interested in the neurosciences through the INP. This was shown by the survey in that many participants agreed that they would take extra neuroscience courses whenever they had the opportunity. It was the instructors' hope that the INP would promote lifelong habits of self-directed learning to some students to continue to explore neuroscience in the quest for updated knowledge. Third, the survey also found no strong correlation between students' pre-chiropractic curriculum and their attitude toward neuroscience. It is interesting to note that nearly all of these respondents believed that the INP considerably increased their confidence and understanding of neuroscience and their ability to learn neuroscience regardless of their diverse pre-chiropractic curriculum backgrounds.

Increase in Neuroscience Content Knowledge

Parallel to the improvement of students' confidence and their ability to learn neuroscience, students' perception of neuroscience content knowledge has also improved based on the results of the survey. Therefore, another goal of the program, to help students to understand the nervous system, seems to have been achieved.

It should be noted that some may argue that the students' perception of neuroscience content knowledge may not reflect 100% of their actual neuroscience content knowledge; a multiple-choice examination may better reflect students' real neuroscience content knowledge level. However, given that there was a wide range of different neuroscience topics covered in the different courses, the number of students involved in the survey, and the limited amount of time allowed for the study, a single real examination does not appear to be realistic to cover all the neuroscience topics for a large number of students during a limited amount of time. Further, there are many other factors that may affect the outcomes of a real examination, such as time for preparation, test skills, and the types of questions tested. Therefore, students' perception of neuroscience content knowledge was the alternative that we selected.

One of the characteristics of this program is to integrate neuroscience context into different courses in the same quarter based on the body system. For example, when the abdominal visceral system is the theme of the quarter, the anatomic, physiologic, and

pathologic features of autonomic innervation will be delivered in conjunction with anatomy, physiology, and pathology courses. In this multiple-aspect approach, students will move beyond the traditional single exposure to the autonomic nervous system to the multiexposure forms of physiologic, anatomic, and pathologic characteristics. The current study suggests that this integration would be an effective approach in delivering neuroscience knowledge to enhance students' neuroscience knowledge and their ability to interpret clinical data. This seems supported by the findings that before taking the INP, students rated their neuroscience content knowledge as very low and improvements seemed to be associated with the implementation of the INP. The majority of students agreed that they gained neuroscience knowledge mainly through the INP.

More importantly, the survey also identified two prominent "negative" outcomes in students' perceived neuroscience content knowledge. One of the negative outcomes was related to the higher functions of the brain. Only a small fraction of upper-quarter students agreed that they were very familiar with such topics as the limbic system, brain stem modulation of pain and movement, and the interaction between the nervous system and the immune system, compared with almost 85% of upper-quarter students who believed that they were very familiar with other aspects of neuroanatomy. Another negative outcome was related to the special senses. Less than half of the students answered in the affirmative, even in the upper-quarter students who have received the lectures on special senses. The results were in agreement with the results of the item analysis of students' performances on the national board examination (data not shown), being strong in structural neuroscience and weak in special sensory neuroscience.

In order to address these perceived deficiencies, the faculty may have to develop more efficient strategies in teaching the higher functions of the brain and special senses. One such strategy would be not only to expand instructors' academic interactions with students, but also to learn more about the needs of students so as to guide students in how to fulfill the course requirements. It is also important for there to be more collaboration among instructors in the courses, because neuroscience is interlinked with different courses at different levels.

Evaluation of Teaching Methods

Faculty members at the college face a number of challenges when teaching neuroscience to chiropractic students with a wide range of educational backgrounds. Additionally, faculty members with different expertise also have to understand a variety of chiropractic philosophies and techniques and how neuroscience can be applied to these philosophies and techniques. Clearly, these factors complicate the already difficult task of instructing students in the theories, techniques, findings, and explanations of neuroscience in chiropractic practice. Therefore, we encourage instructors to apply Bybee's 5E (Engage, Explore, Explain, Elaborate, and Evaluate) model[14] of instruction in their teaching. The purposes of these 5Es is to grab the students' consciousness when neuroscience information comes up in different courses, to put students into a receptive frame of mind about how to absorb neuroscience within the courses taught, and to create an organizing framework for neuroscience information and other topics. Obviously, the next logical question of the survey would be to assess the efficiency of this teaching model.

The analysis of the survey revealed that a considerable number of participants (79%) still considered the classroom lecture as a main approach of learning neuroscience, especially among the lower-quarter students. Therefore, instructors' performance in the classroom might directly affect the students' learning process. The upper-quarter students showed more independent learning styles; instead of relying on classroom instruction only, more upper-quarter students used other sources, such as the Internet and software, than lower-quarter students, suggesting that replacing passive learning with more active learning has been associated with an increased perception in neuroscience content knowledge.

Students also thought that the laboratory was a necessary supplement to the classroom lectures, because the laboratory might provide visual supplementation, which was hard to present in the classroom. However, slightly more than half of the students agreed that the ALS was a valuable tool for neuroscience learning. The purpose of the ALS was to provide an opportunity for students to actively apply their basic neuroscience knowledge to clinical situations. This rate was lower than the college's expectation. The low rating of ALS activities could be a result of the types of cases used, because these cases involved a broader spectrum of knowledge

and not just the neurosciences. We believe that by adding teacher-guided inquiry, hands-on activities, and follow-up discussion, active leaning would be enhanced.

Limitation of the Study

The study has several limitations. First, this evaluation relies on self-reported data and is therefore subject to recall and social bias. In an effort to keep bias to a minimum, we tried to construct a survey instrument that was clear, unambiguous, and appropriately worded for students. Importantly, we only presented items that asked what we needed to know to gauge our success in meeting the goal of the survey. Second, the coverage of students was not perfect, because students in their final year were not surveyed because of their clinic commitment. Third, the participants' perception of neuroscience content knowledge equates completely with their actual knowledge; therefore, comparisons between real test results and the survey could be used. Finally, the time limitation was another disadvantage of the study because we wanted the study to be finished in the current quarter and the outcomes reflected that situation. However, a dynamic survey would achieve more comprehensive results.

CONCLUSION

The educational goals of teaching neuroscience in chiropractic schools differ from medical, graduate, and other health-related courses significantly. Consequently, it is not surprising that the implementation of the INP is the choice. This survey showed that the INP provided by Palmer College of Chiropractic Florida successfully boosted students' attitudes toward neurosciences and their content knowledge. Some negative outcomes were also identified. The information yielded from this survey may be useful in helping neuroscience teachers at the college in developing more effective strategies in teaching neuroscience.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

Received, April 27, 2008
Revised, October 29, 2008; April 5, 2009
Accepted, April 26, 2009
Address correspondence to: Xiaohua He, MD, Palmer College of Chiropractic Florida, 4777 City Center Parkway, Port Orange, FL 32129; Shawn.He@palmer.edu.

REFERENCES

1. Lantz CA. A review of the evolution of chiropractic concepts of subluxation. Top Clin Chiropr 1995;2:1–10.
2. Lantz CA. The vertebral subluxation complex. Part 2: The neuropathological and myopathological components. Chiropr Res J 1990;1:19–38.
3. Kent C. Wellness care, health, subluxations, and remedial education. J Manipulative Physiol Ther 2002;25:423–5.
4. Wilkey A, Gregory M, Byfield D, McCarthy PW. A comparison between chiropractic management and pain clinic management for chronic low-back pain in a national health service outpatient clinic. J Altern Complement Med 2008;14:465–73.
5. Schellingerhout JM, Verhagen AP, Heymans MW, et al. Which subgroups of patients with non-specific neck pain are more likely to benefit from spinal manipulation therapy, physiotherapy, or usual care? Pain Sep 4, 2008 [Epub ahead of print].
6. Fernández-de-Las-Peñas C, Alonso-Blanco C, Cuadrado ML, Pareja JA. Spinal manipulative therapy in the management of cervicogenic headache. Headache 2005; 45:1260–3.
7. Pickar JG, Ge W. Time course for the development of muscle history in lumbar paraspinal muscle spindles arising from changes in vertebral position. Spine J 2007;7:583–95.
8. Pickar JG. Neurophysiological effects of spinal manipulation Spine J 2002;2:357–71.
9. DeVocht JW, Pickar JG, Wilder DG. Spinal manipulation alters electromyographic activity of paraspinal muscles—a descriptive study. J Manipulative Physiol Ther 2005;28:465–71.
10. Ge W, Long CR, Pickar JG. Vertebral position alters paraspinal muscle spindle responsiveness in the feline spine: effect of positioning duration. J Manipulative Physiol Ther 2005;569:655–65.
11. Budgell BS. The reflex effects of subluxation: the autonomic nervous system. J Manipulative Physiol Ther 2000;23:104–6.
12. Likert R. A method of constructing an attitude scale. In: Maranell GM, ed. Scaling: a sourcebook for behavioral scientists. Chicago: Aldine Publishing; 1974, pp. 233–43.
13. Bandura A. Self-efficacy. In: Ramachaudran VS, ed. Encyclopedia of human behavior, vol 4. New York: Academic Press; 1994, pp. 71–81.
14. Bybee, RW. Achieving scientific literacy: from purposes to practice. Portsmonth: Heinemann; 1997.

APPENDIX
Student Questionnaire

The purpose of this survey is to capture your understanding and anticipated attitude toward neurosciences taught in Palmer College of Chiropractic Florida through INP. All responses will be kept anonymous. **For this survey, we define "neuroscience education" to include neuroanatomy, neurodevelopment, neurophysiology, neurochemistry, neuroimaging, neuropathology, genetics, and research.**

Demographic Information

1. Quarter: 1 2 3 4 5 6 7 8 9
2. Gender: Male Female
3. Ethnic group: White Black Hispanic Native Asian Jewish Arab
4. Age:
5. Undergraduate degree:

Description of Your Attitude Toward Neuroscience

1. Description of your confidence scores in learning neuroscience (Δ for the time of admission; ◯ for the time surveyed)
   1 2 3 4 5 6 7 8 9 10
2. Neuroscience is important and will help you to understand the mechanism of chiropractic therapy.
   a. Agree b. Somewhat c. Disagree
3. Integrated Neuroscience Program excited you about neuroscience.
   a. Agree b. Somewhat c. Disagree
4. The Integrated Neuroscience Program provided valuable experience.
   a. Agree b. Somewhat c. Disagree
5. You will take more neuroscience courses if the opportunities are provided.
   a. Agree b. Somewhat c. Disagree
6. Every student has to be well acquainted with neuroscience knowledge.
   a. Agree b. Somewhat c. Disagree
7. Neuroscientific way of thinking is dull and boring to chiropractic.
   a. Agree b. Somewhat c. Disagree
8. Neuroscience is the only way to explain chiropractic therapy.
   a. Agree b. Somewhat c. Disagree
9. Which of the following elements do you think is the most important factor that influences your attitude toward neuroscience?
   a. neuroscience courses provided through Integrated Neuroscience Program
   b. instructors who delivery the courses
   c. student-teacher interaction
   d. teaching materials
   e. role model of other students
   f. your previous background
   g. size of classroom
   h. family members' influence
   i. your career interest
   j. your academic ability

Your Neuroscience Content Knowledge (Knowledge Levels: Agree: well; Somewhat; Disagree: poor)

10. Rate your neuroscience knowledge at the time of admission (Δ) and at the time of survey (◯).
    0 1 2 3 4 5 6 7 8 9 10

11. Classification of the nervous system
    a. Agree b. Somewhat c. Disagree

12. Anatomical organization of the nervous system
    a. Agree b. Somewhat c. Disagree

13. Functional organization of the nervous system
    a. Agree b. Somewhat c. Disagree

14. Integration of sensory and motor functions
    a. Agree b. Somewhat c. Disagree

15. Topographic brain anatomy
    a. Agree b. Somewhat c. Disagree

16. Topographic spinal cord anatomy
    a. Agree b. Somewhat c. Disagree

17. Microscopic neuroanatomy
    a. Agree b. Somewhat c. Disagree

18. Development of the nervous system
    a. Agree b. Somewhat c. Disagree

19. Cytology in relation to its physiological features of a neuron
    a. Agree b. Somewhat c. Disagree

20. Membrane and action potentials
    a. Agree b. Somewhat c. Disagree

21. Neuronal communication
    a. Agree b. Somewhat c. Disagree

22. Synaptic transmission
    a. Agree b. Somewhat c. Disagree

23. Neurotransmitters and their actions
    a. Agree b. Somewhat c. Disagree

24. Three main neural pathways in the spinal cord
    a. Agree b. Somewhat c. Disagree

25. Visual pathway and vision
    a. Agree b. Somewhat c. Disagree

26. Hearing pathway and audition
    a. Agree b. Somewhat c. Disagree

27. Neural control of movement
    a. Agree b. Somewhat c. Disagree

28. Motor unit formation
    a. Agree b. Somewhat c. Disagree

29. Spinal reflex and mechanism
    a. Agree b. Somewhat c. Disagree

30. Voluntary movement
    a. Agree b. Somewhat c. Disagree

31. Brain stem and structure
    a. Agree b. Somewhat c. Disagree
32. Cranial nerves and their lesions
    a. Agree b. Somewhat c. Disagree
33. Nuclei in the brain stem
    a. Agree b. Somewhat c. Disagree
34. Brain stem modulation of sensation and movement
    a. Agree b. Somewhat c. Disagree
35. Anatomy of autonomic nervous system
    a. Agree; b. Somewhat c. Disagree
36. Physiology of autonomic nervous system
    a. Agree b. Somewhat c. Disagree
37. Vasculature of the brain and spinal cord
    a. Agree b. Somewhat c. Disagree
38. Anatomy of cerebellum
    a. Agree b. Somewhat c. Disagree
39. Cerebral cortex and its function
    a. Agree b. Somewhat c. Disagree
40. The function of the limbic system
    a. Agree b. Somewhat c. Disagree
41. The function of the basal ganglion and its clinical implication
    a. Agree b. Somewhat c. Disagree
42. Pain and pain modulation
    a. Agree b. Somewhat c. Disagree
43. The structure and function of the thalamus
    a. Agree b. Somewhat c. Disagree
44. The structure and function of the vestibular system
    a. Agree b. Somewhat c. Disagree
45. Brain higher function (such as cognition, and how they interact with structures involved in guiding our behavior)
    a. Agree b. Somewhat c. Disagree
46. Nervous and immune system interaction
    a. Agree b. Somewhat c. Disagree
47. Nerve degeneration, regeneration and plasticity
    a. Agree b. Somewhat c. Disagree
48. Which of the following elements do you think is the most important factor to influence your improvement of neuroscience content knowledge?
    a. neuroscience knowledge learned through Integrated Neuroscience Program
    b. instructors who delivery the courses
    c. student-teacher interaction
    d. teaching materials
    e. role model of other students
    f. your previous background

g. size of classroom
h. family members' influence
i. your career interest
j. your academic ability

Integrated Neuroscience Program in Your Curriculum: Teaching Efficiency

49. The integrated neuroscience program is worthwhile for my time.
    a. Agree b. Somewhat c. Disagree
50. Classroom lectures fulfill their goal to help understanding neuroscience.
    a. Agree b. Somewhat c. Disagree
51. Laboratory sessions fulfill their goal to help understanding neuroscience.
    a. Agree b. Somewhat c. Disagree
52. Active learning sessions fulfill their goal to help understanding neuroscience.
    a. Agree b. Somewhat c. Disagree
53. Internet, software, and self-study help to understand neuroscience.
    a. Agree b. Somewhat c. Disagree
54. Overall quality of instructors are highly satisfactory.
    a. Agree b. Somewhat c. Disagree
55. The overall quality of Integrated Neuroscience Program is highly satisfactory.
    a. Agree b. Somewhat c. Disagree
56. Your expectation of learning neuroscience is highly satisfactory.
    a. Agree b. Somewhat c. Disagree
57. Do you agree neuroscience information is integrated into the other courses, such as anatomy, physiology, biochemistry, etc.?
    a. Agree b. Somewhat c. Disagree
58. Which of the following is the major way you learn neuroscience?
    a. classroom lecture
    b. laboratory
    c. active learning section
    d. self-reading
    e. Internet
    f. software
    g. out campus seminar